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Diesel Railway Traction

French Journey

WHEN describing the new articulated 500 b.h.p. Renault diesel-mechanical railcar on the French State Railways, in the issue of this Supplement for September 7, we mentioned that it was intended for use on the Paris-Caen line. Recently we had the opportunity of making a double trip on this service and were impressed with the general performance and with the layout of the vehicle. The car is painted dark red below the waist line and French grey above. In the first and second class compartment there are 36 tubular armed seats of latex rubber upholstered in plush, and they are very comfortably shaped, although a trifle small for a bishop. The third-class seats are arranged two on one side and three on the other of a central gangway and are upholstered in leather. A supplement of 10 fr. is charged to third-class passengers, but if the journey is short the passenger may pay the difference between second and third class fares if this is cheaper. Noticeable features of the journey were the scarcely audible noise of the engines and the absence of dirty smoke, and smell in the passenger compartment. The ventilation on the outward journey was good, but returning to Paris in the cool of the evening there was a good deal of draught to be felt, which apparently came from the roof ventilators, as all the windows were shut. Although both articulated units are symmetrical so far as underframe, bogies, and engine layout are concerned, we noticed more side-to-side oscillation with the first and second class end leading, but the vertical movements were negligible. The logs of the return trip between Paris and Caen are given below.

Miles from Paris			Actual time	Booked time
—	Paris (St. Lazare) ..	dep.	1.40.20	1.40
10·50	Maisons Lafitte	pass	1.51.25	
13·75	Acheres	,,	1.53.35	
36·00	Mantes	,,	2.12.55 (slow)	
67·00	Evreux	arr.	2.45.10	2.47
		dep.	2.47.45	2.48
92·50	Serguigny	pass	3.11.35	
98·75	Bernay	,,	3.17.05	
118·75	Lisieux	arr.	3.36.35	3.39
		dep.	3.39.45	3.40
134·25	Mezidon	pass	3.56.10	
148·50	Caen	arr.	4. 9.45	4.10

The maximum speed, attained several times, was 78 m.p.h. Coming back we arrived in Paris only $\frac{1}{4}$-min. late despite a late start of one minute and a long slow at Acheres, the details of the run being as given below.

Miles from Caen			Actual time	Booked time
—	Caen	dep.	5.31. 0	5.30
29·75	Lisieux	arr.	5.59.50	6.01
		dep.	6. 3.35	6.02
81·50	Evreux	arr.	6.52.00	6.54
		dep.	6.54.55	6.55
112·50	Mantes	pass	7.24.45 (slow)	
			Long slow at Acheres	
148·50	Paris (St. Lazare) ..	arr.	8. 0.15	8.00

The acceleration of the car was good, a speed of 60 m.p.h. being attained within three minutes of leaving Lisieux, and gear-changing was almost imperceptible. On the outward journey the car was about three-quarters full, but coming back every seat was occupied and camp chairs were in use in the gangway; even so, people were left behind at Evreux, and it was evident that this new diesel service lacked nothing in popularity.

Experience—at a Price

IT is now generally known that the 35 Maybach-engined diesel-electric trains of the Netherlands Railways have been temporarily withdrawn from service due to engine breakdowns. The causes of the failures, however, were not altogether in the engines themselves. In the first place, the characteristics of the transmission appear to have been chosen erroneously, with the result that the engines, which were arranged to run at variable speed, were operating for much of the time at or about 800 r.p.m., instead of near the rated speed of 1,400 r.p.m. It was originally intended that 800 r.p.m. should be the idling speed, but as actual service conditions required an output of well over 200 b.h.p. at this speed, the m.e.p. was above the maximum value for which the engine had been designed. Secondly, some trouble was occasioned by fuel pipes cracking and the pipe joints leaking, thus causing air-locks to develop in the fuel system, and constant interruptions to occur in the supply to the cylinders. Finally, the inexperience of the staff led to the oil filters becoming choked through lack of cleaning. As might be expected (now the facts are known), after a few weeks' work car after car failed, until it was thought desirable to withdraw the complete stud in order that the origin of the mishaps could be thoroughly investigated. Several pistons were broken, a few crankshafts fractured, and one or two cylinder walls cracked. (No liners are used in these engines.) The complete withdrawal of the large number of units involved has led to a good deal of reproach, but, according to a statement made by the responsible engineer of the owning company, the troubles can be rectified, and we understand that some of the vehicles will be back in traffic by the beginning of December. Perhaps the faults may be traced to the extreme haste with which the order was executed, for instructions were given for the design and construction of the trains at the end of February, 1933, on the understanding that all would be in service by May 15, 1934. Of course, it is easy to be wise after the event, but as regards such an important matter as transmission characteristics, it is no more trouble to choose rightly than to choose wrongly, and in view of the data available at the time from cars having the same type of engine and engaged in similar duties, we think that the price of the Dutch experience may possibly have been higher than necessary. For the construction and mechanical design of the cars we have nothing but praise, and it is to be hoped that the modifications now being made will remedy the operating defects *in toto* and not merely in part. The five train sets with Stork-Ganz engines have not yet seen any line service, but it is intended to place them in traffic within the next few days, and the winter timetable shows the running of six diesel trains between Amsterdam and Eindhoven.

OPERATING EXPERIENCE WITH DIESEL RAILCARS IN SPAIN

Exceptionally reliable service has been obtained from the three Beardmore-engined vehicles on the Pamplona-San Sebastian Railway over a period of nearly six years

AT the end of 1928, Wm. Beardmore & Co. Ltd. shipped to Spain three 200 b.h.p. diesel-electric railcars for service on the so-called Pamplona-San Sebastian Railway, a metre-gauge line which is owned by the Soc. Minera Guipuzcoana, and since that time these cars have been constantly engaged in passenger traffic over the 57 miles separating the two terminal stations named in the railway's designation. The mechanical portions of the cars were built by Clayton Wagons Limited and the electrical equipment by the English Electric Co. Ltd.

The cars are of the double-bogie type with a seating capacity of 12 first and 18 third class passengers, and 30 sq. ft. of luggage room, on an empty weight (with supplies) of 33 tons. Normally, two trailers each weighing 16 tons gross can be hauled, and the total train weight is then 67 tons, which load must be worked up grades as steep as 1 in 37, and up a continuous rise of 21 miles with a difference in level of approximately 1,900 ft.

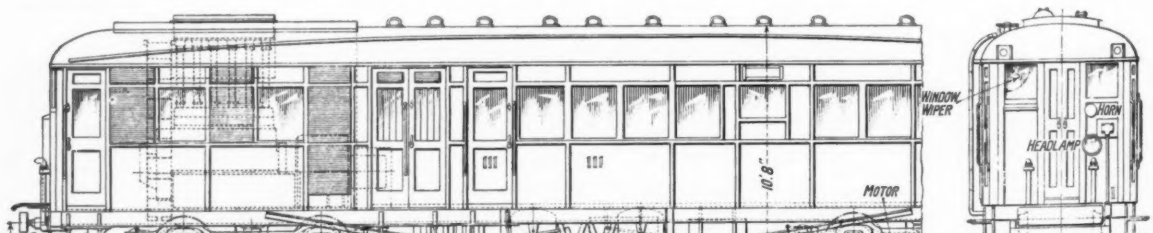
Power is supplied by a four-stroke Beardmore engine developing 200 b.h.p. at 1,250 r.p.m. in six cylinders having a bore of 6·5 in. and a stroke of 9 in. The general arrangement of this light-weight engine is given in one of the accompanying illustrations, from which may be seen the monobloc form of the crankcase, and the rigid and well-supported crankshaft. The engine is started electrically, for which purpose current is supplied to the main generator from a battery which also provides current for the auxiliaries and the car lighting. Braking is on the vacuum system with blocks attached to all wheels, the braking force being supplied from two cylinders, one of 21 in. diameter and one of 18 in. diameter. A supplementary hand brake is provided in each driving compartment. The maximum speed is limited to 70 km.p.h. (44 m.p.h.). The third class seats are of wood, but those in the second class compartment are upholstered. The layout of the car and the principal dimensions are shown on the accompanying arrangement drawing.

Service

The three railcars make an average yearly aggregate kilometrage of 140,000 (87,000 miles), the normal daily run per car being one return trip between San Sebastian and Pamplona, a distance of 185 km. (115 miles). The service is maintained on the basis of one driver one car, as the round trip can be covered within the eight-hour working day. On occasions, two round trips have been made in a day.

For unusual conditions, such as rush periods or holiday traffic, trains are made up of two or three railcars working in multiple unit with a number of trailers, the whole set being controlled by one driver. The maximum composition of such a train which has so far been operated was made up of the three railcars with five trailers. In the event of a breakdown on the line, the car is assisted by a reserve unit or by a steam locomotive, but this has rarely been necessary, as shown later. No alteration to the signalling, crossings, or alignment of the track was necessary on account of the introduction of diesel traction.

The drivers of the railcars were recruited from the ranks of the steam locomotive drivers and firemen, and the selected few found no difficulty in adapting themselves to the operation of the diesel cars, not only on the road,



General arrangement of Beardmore diesel-electric railcar on the Pamplona-San Sebastian Railway

General view of metre-gauge 200 b.h.p. diesel-electric railcar

but also in the work involved in the running sheds and repair shops. Maximum and minimum wages of the steam locomotive drivers on the lines of the owning company are 414·93 pes. and 333·5 pes. per mensem on the basis of an eight-hour day. When the railcars were put into operation, certain spare drivers were offered the post of railcar driver at a salary of 242·7 pes. a month, which they accepted. The wages of the remainder of the staff concerned with the railcars are as follow:

Fitter-erector	260–300 pes. per mensem.
Fitter	8·5–9 pes. per 8-hour day.
Turner	220 pes. per mensem.
Carpenter	7·5–8·5 pes. per mensem.
Smith	9 pes. per 8-hour day.
Labourer	7 pes. per 8-hour day.

The emoluments of the guard average 0·043 pes. per km., equivalent to the pay of the driver.

Working Costs

Taken over a year, the consumption of fuel is 0·81 kg. per km. (2·87 lb. per mile), and 0·015 kg. per tonne-km. (0·054 lb. per ton-mile); the lubricating oil consumption amounts to 0·0309 kg. per km (0·1095 lb. per mile), and 0·0007 kg. per tonne-km. (0·0025 lb. per ton-mile). The cost of the fuel averages 0·348 pes. per kg., and that of the engine lubricating oil 3·3 pes. per kg. The net operating cost of 0·491 pes. per km. (0·791 pes. per mile, or 5·35d. at the present rate of exchange), is made up as given below:

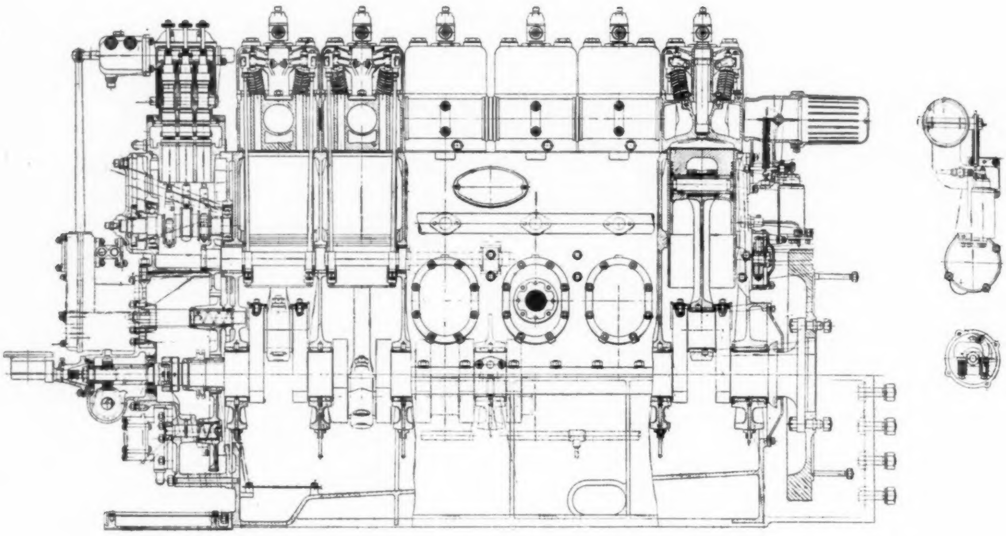
	Pes. per km.
Fuel	0·282
Lubricating oil (engine)	0·102
Lubricant for transmission	0·004
,, for axle-boxes	0·011
Gear oil	0·006
Driver's wages	0·043
Guard's wages	0·043
Total net operating cost	0·491

Maintenance

At the terminal stations a separate shed has been constructed for housing the railcars during the night, in order to protect the engine from the weather and the severe frosts (10 deg. C. below zero at Pamplona), and also to keep the cars free from smoke and coal dust from the steam locomotives. The driver of the railcar, with the assistance of the running shed labourer, carries out any small repairs which are necessary at the end of the day. The wages of the steam shed workman are 8 pes. per 8-hr. day, and of the carriage shed employee, 5·5 pes. per 8-hr. day.

When the train arrives at the terminus, the driver inspects the diesel engine, cleans it externally, adjusts the

200 b.h.p. Beardmore diesel-electric railcar hauling two trailers on the Pamplona-San Sebastian Railway



Longitudinal section of 200 b.h.p. six-cylinder Beardmore high-speed diesel engine

valves if necessary, cleans the filters, and fills the oil boxes of the traction motors. Then, assisted by the running shed workman, he overhauls the vacuum brake, oils and adjusts the brake rigging, and, if required, renews the brake blocks. Every eight days the driver and running shed labourer change the lubricating oil of the engine (120 litres or 54 gals.). At each end of the run the drivers make and break the trains, and carry out any shunting work which may be necessary. This work and the overhauling occupy about three hours a day driver's time, and one-and-a-half hours labourer's time. The estimated proportion of the wages per km. for this maintenance is 0·024 pes. per km., of which approximately two-thirds is chargeable against the driver and one-third against the labourer. Sundry yard charges, including the cost of cleaning material, water, charging of batteries, and odd stores, amount to 0·016 pes. per km.

Periodic light overhauls of the diesel engine are carried out in a closed shed which is kept as clean as possible. It has also been found most desirable that the cleanliness should extend to the workmen and tools. The average distance covered by a car between two light overhauls is 18,000-20,000 km. (11,000-12,500 miles). No change has been made in the personnel of the workshops. On the occasion of these overhauls the cylinder heads and pistons are dismantled and cleaned, and the exhaust valves lightly ground in; the piston rings are cleaned; the big-end brasses are examined and tested for clearance; the fuel injectors are examined and tested; and the crankcase, lubricating oil reservoir and filters are cleaned. The time required for overhauling the diesel engine is approximately six days of eight hours, with two fitter-erectors, and a labourer for cleaning. Among the materials regularly used at these shoppings are 12 paper joints, 12 rubber rings for cooling water pipe joints, 6 cork joints for the heads, and 6 asbestos sheet washers for the exhaust pipe joints. Piston rings and copper washers for joints are sometimes used again. The battery is inspected at the same time, given a fresh charge, and the density of the electrolyte corrected.

Attention to the mechanical portion includes inspection and adjustment of the bogies, axleboxes, brakes, and underframes, and all the bodywork details such as doors, seats, framework, and blinds are examined. The average cost of a periodic overhaul amounts to 429·65 pes., or 0·0226 pes. per km., made up as follows:—

	Pes.
Labour costs	323·40
Material charges	79·98
Sundries, cleaning materials	26·27
Total, light overhaul cost	429·65

The total cost of operation, including maintenance and light periodic overhauls is therefore 0·491 plus 0·024 plus 0·016 plus 0·0226 pes., or 0·5536 pes. per km. (6·03d. per mile).

Heavy Overhauls

Both the staff and the machines used for heavy repairs are the same as those employed in steam days, and the workers are the same as those who carry out the light periodic overhauls. Two fitter-erectors with one or two labourers do most of the work, and there is only one electrician, who has charge of the maintenance of everything electrical on the whole railway, this including the line, stations, rolling stock, and 90 km. of telephone line.

In addition to the periodic light overhauls detailed above, the cars are brought into the shops for a thorough repair after every 100,000-130,000 km. (62,000-80,000 miles). By a heavy overhaul is understood the complete inspection of the diesel engine, which means the dismantling and careful examination of each detail and accessory; the adjustment and renewal of any parts showing excessive wear; the lining up of the bearings and grinding in of the valves and joints; cleaning the inside and outside of the water and oil coolers, piping, fans, pumps, tanks, and filters.

On the transmission side, the main and auxiliary generators, four traction motors, switchboard, control gear, and cables are dismantled and cleaned, and the battery inspected and re-conditioned. The work also entails the dismantling of the bogies, truing up the tyres, lining the axlebox bearings, adjusting the horn plates, repair and renewal of the vacuum brake and brake rigging, inspection and cleaning of the bodywork, roof, seats, doors, window frames, and blinds, and painting and varnishing the car, inside and out.

A heavy overhaul of this character occupies about two

months. The work of overhauling the diesel engine and its accessories is done by two mechanics and two labourers, taking between **30** and **40** days; the electrical portion is done by the one electrician, and takes about **15** days. The overhaul of the bogies and coachwork is equivalent to what is required by a metal coach after two years' service. The tyres are occasionally trued up during a periodic light overhaul, the average distance between two turnings being **45,000** km. (**28,000** miles), or approximately one year's service.

The cost of the heavy overhaul is roughly **2,300** pes. (**£65** at the present rate of exchange—**35½** pes. to the **£**), and is made up as indicated in the following tables:

Labour Charges

	Pes.
Diesel engine	760·15
Radiators and fans	83·10
Electric installation	28·60
Traction motors and generators	70·23
Mechanical portion	618·65
Coachwork	21·26
Accumulators	9·20
Painting	144·00
Total, pes.	1,735·19

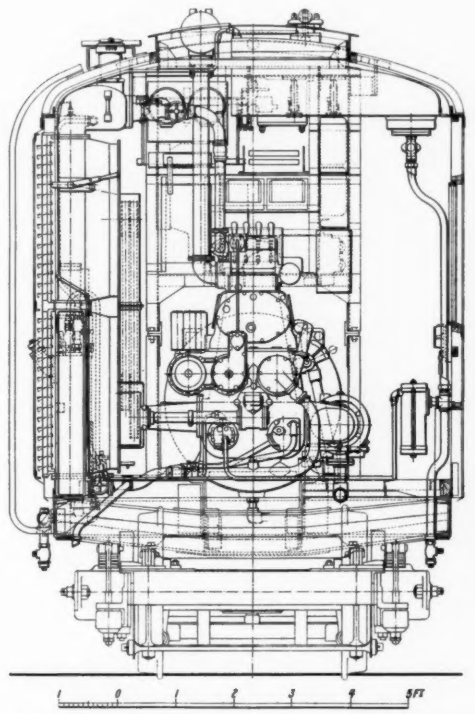
Material Cost

Diesel engine and accessories	155·11
Electric installation	2·09
Mechanical portion	170·57
Coachwork	16·52
Material for cleaning and painting the railcar :—	
Engine and coach	25·13
Cleaning coachwork and painting	199·92
Total, pes.	569·34

On a mileage basis the cost is therefore **2304·53/120,000**, which is equal to **0·0192** pes. per km. or **0·21**d. per mile, of which labour charges are responsible for **75** per cent.

Equipment and Stores

Although the machine tools in the shops have not been increased in number or variety, the equipment has been added to by the installation of an electric charging plant for maintaining the batteries (utilising the old Stone's dynamos of electrically-lighted coaches), and a plant for cleaning and recovering the engine lubricating oil, in order to use it afresh. At Andoain station has been installed a fuel tank with a capacity of **15,000** litres (**6,800** gal.), a fuelling plant, and a centrifugal filtering apparatus. The cars take in fuel at Andoain once a day, and the time occupied in taking on board **180** litres (**81** gal.) is a minute and a half. Reserve electrical installa-



Cross-section of diesel railcar, showing power equipment

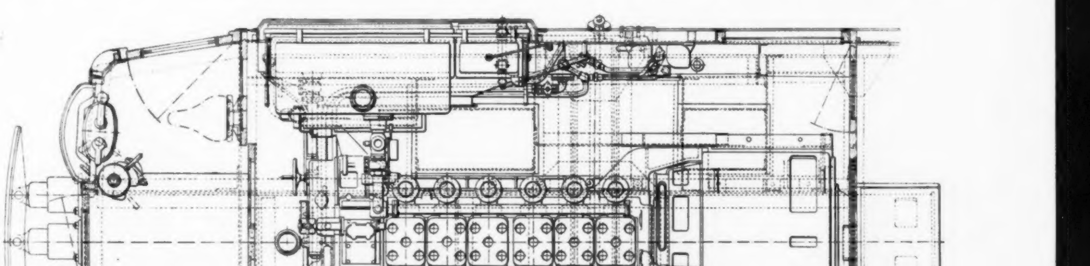
tions and fuel tanks are fitted in the sheds at each terminal station, for use in the event of the line being blocked by landslides or floods.

The store contains **300** items, of which the yearly issue of the parts requiring regular replacement is as follows:

Cork joints	76	Aggregate number of items required by three railcars.
Brush segments	12	
Valve segments	3	
Rubber joints	178	
Copper washers	30	
Injection nozzles	2	
Fan pulleys	4	
Fuses	8	
Brushes	70	
Brush-holder insulators	2	
,, springs	2	
Vacuum-brake diaphragms	6	

The spare parts in the above list are all small, and the

Plan of engine and driving compartments of 200 b.h.p. diesel-electric railcar, Pamplona-San Sebastian Railway. At the other end of car the driving cab is against the passenger compartment



average value of the lot can scarcely amount to more than a few pounds sterling.

Breakdowns

Details of the breakdowns and accidents which caused delays during the period from August, 1932, to the end of July, 1934, are given below.

RAILCAR NO. 1.

November 16, 1932, to July 31, 1934.

Km. run during this period, 77,705 (48,250 miles).

September 28, 1933.

The train was stopped *en route* to open the automatic safety switch on the electrical installation. After a stop of three minutes to ascertain the cause of the short circuit and cutting out the electric traction motor which had earthed, the train proceeded without further incident. On arrival at the terminus, the traction motor which caused the delay to the train was inspected, and it was found that the insulator of a brush holder was split.

January 3, 1934.

The train was held up at Olloqui owing to breaking of the balls in a ball bearing of the fan control gear. The train was hauled to Pamplona by a steam locomotive.

RAILCAR NO. 2.

August 1, 1932, to July 31, 1934.

Km. run during this period, 82,480 (51,200 miles).

October 1, 1932.

An exhaust valve seized between Olloqui and Plazaola, seven minutes being lost while freeing this valve with petrol.

October 3, 1932.

At 68 km. the oil fuel feed pipe of No. 1 injector broke, losing 14 min. while replacing the broken pipe from the spares which are carried on each railcar.

October 31, 1932.

Train No. 3 (railcar No. 2) left Pamplona 10 min. late, as the diesel engine could not be started owing to the fracture of a fan pulley.

July 3, 1933.

Train No. 1 left Pamplona 30 min. late owing to difficulty in starting the diesel engine when endeavouring to start with the accumulators. The battery was found to have four defective cells. (These cells had been in service for 4½ years.)

October 8, 1933.

24 min. were lost *en route* at 41 km. and 17 min. at Huici, through the battery fuse blowing. The spare fuse was also found to be blown.

RAILCAR NO. 3.

September 26, 1932, to July 31, 1934.

Km. run during this period, 91,842 (57,000 miles).

December 1, 1932.

Train No. 2 (railcar No. 3) was stopped for 20 min. at km 72 in order to replace the injector nozzle with the spare one. The tip of the atomising nozzle of the faulty injector had broken.

December 17, 1932.

When engaged in making up train No. 3 at Pamplona, railcar No. 3 was stalled owing to a fault in the electrical installation. An earth was found at the end of the supply cable of one of the solenoids actuating the oil relay of the change-speed gear of the diesel engine.

December 18, 1932.

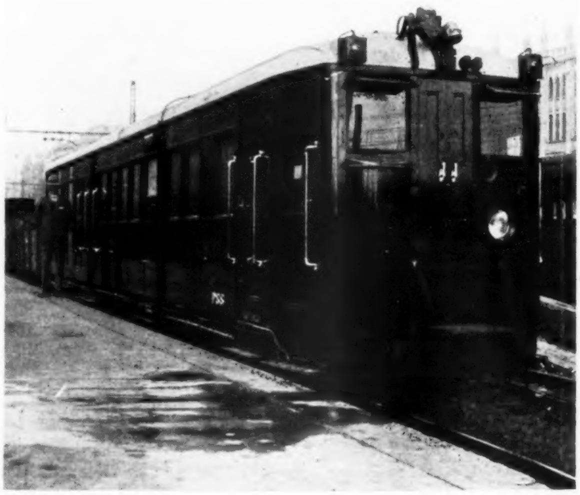
When getting train No. 2 (railcar No. 3) ready for work, the driver noticed that the oil pressure had gone; the diesel engine was stopped as a precaution, and the reserve machine called upon. Inspection of the engine showed that the mechanic, when cleaning the crank case for changing the oil, had left in a piece of cleaning cloth which had blocked the suction pipe of the oil pump. This act of negligence occasioned no damage to the engine.

January 23, 1933.

Owing to the extreme cold, the oil clogged, and the starting battery failed to work. Consequently the driver could not start up railcar No. 3 for taking charge of train No. 2 from San Sebastian. The train was hauled by a steam locomotive, and on arrival at Andoain, the electrician bridged over the faulty cells in the battery and the diesel engine was started, the train being then hauled from Andoain by the railcar. Six cells in the battery were replaced. (They had been at work for four years.)

February 15, 1933.

Train No. 3 (railcar No. 3) was stalled at Latasa through the battery running down, and had to be hauled by a steam locomotive. A brush on the main generator exciter was broken in pieces, at which the whole of the current produced by the exciter passed through the next positive brush which was in parallel with the first; this second brush heated up through taking the current through the connecting piece, and the heat put the brush pressure spring out of action. The spring not operating, this second brush lost contact, and accordingly the exciter produced no current. The battery at this point, and for several hours, was called upon to supply the exciting current for the main generator, and at the same time to supply current to the vacuum brake pump motor, the control gear, and the lighting. As the battery was not assisted by the exciter for some hours, it became discharged. This deprived the main generator of exciting current, and the train was brought to a standstill, with the engine still running.



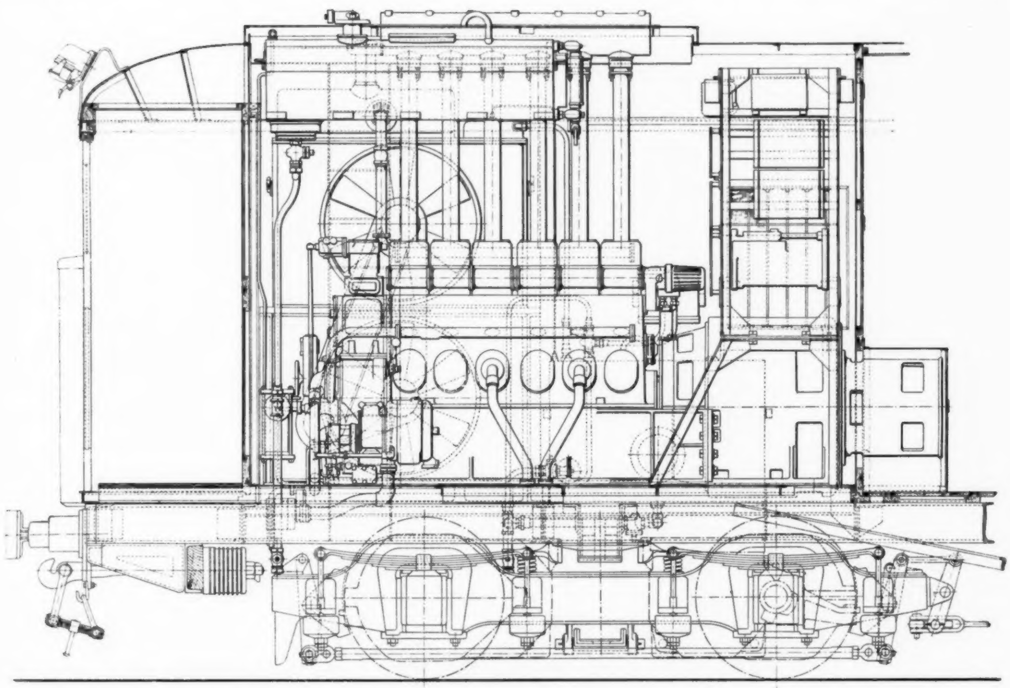
Diesel-electric railcar at San Sebastian (Amara) station

August 21, 1933.

Train No. 3 (railcar No. 3) was stopped for 7 min. between Lasarte and Anorga owing to the earthing of a brush holder insulator on one of the traction motors; this motor being cut out, the train proceeded on three motors without further incident.

January 14, 1934.

Train No. 3 (railcar No. 3) was stopped at km. 80



Sectional elevation of engine room of Pamplona-San Sebastian Railway diesel-electric railcar

owing to a lack of cooling water. This was due to the driver, who, at Pamplona, did not fully close the water drain cock, so that the radiator was emptied *en route*.

Financial Charges and Depreciation

The final price of each railcar supplied to the Pamplona-San Sebastian Railway, as quoted on November 26, 1927 by Wm. Beardmore & Co. Ltd., delivered complete and ready for the road, was **274,000** pes., or **£9,450** at the then prevailing rate of **29** pes. to the **£**, including import duties.

In considering the amortisation of the railcars there must be taken into account (*a*) mechanical portion, (*b*) electric transmission, (*c*) diesel engine and auxiliaries. The depreciation of the mechanical portion may be taken as the same as that of a bogie passenger coach of strong construction. The transmission, in view of its robust design, freedom from trouble, small wear and tear, and ease of repair, may be assigned an amortisation corresponding in years to an electric motor coach, some of which, owned by the same company, have given a service of **31** years, and others **22** years, and are still running with a maximum yearly kilometrage of **64,500**.

Regarding the diesel engine, the conclusions reached in the official acceptance report dated July **2**, **1931**, have been fully confirmed by the subsequent service. This report stated that although the work done did show that the railcars had more than complied with the specified guarantee conditions, yet, as an unknown quantity might exist and cause a doubt as to the adoption of this system of traction in place of steam, when coming to a decision regarding the period and cost of amortisation per train-km. for the diesel engine, the scope of the inspection and study of the engine was extended in order to remove and clear up this unknown quantity, by completely dismantling all the parts of railcar No. 1 and measuring and examining in minute detail each individual part, ascertaining the amount of wear and estimating the probable life of each part from the results obtained after the **53,000** km. (**33,000** miles) running of railcar No. **1**. Further observations commented upon the excellent conditions of durability which were found, and upon the foresight of the makers in designing the engine in such a way that all parts liable to wear were easily replaced,

When making the above-mentioned inspection, a very careful classification was made of the parts subject to wear, and the probable life of each was determined in train-km. The result of this investigation showed that the costs per km. of spares for parts most subject to wear and tear, with the exchange at 29·00 pes. to the £, was 0·224 pes. per train-km.

Although this figure of 0·224 pes. per train-km. may be used in determining the depreciation of the engine, it may be considered that after **15** years or so the engine will be obsolete, despite its capacity for further service, and therefore depreciation should rather be calculated on the basis of depreciation to zero in that time, or say on a mileage of **750,000** km. The price of the engine installed in these railcars was **£2,100**, and the accessories **£365**, giving a total at **29** pes. to the **£** of **71,485** pes. plus **11,000** pes. customs duties, or **82,485** pes. On this cost the depreciation spread over **750,000** km. amounts to 0·11 pes. per km. Present first costs are much lower.

Summary

From this report it may be seen that the results of working the Beardmore railcars on the San Sebastian-Pamplona line give the following figures per train-km. :—

Net operating cost	0·4910	pes. per km.
Daily maintenance cost	0·0400	,, ,,
Periodic light overhaul	0·0226	,, ,,
Heavy overhaul	0·0192	,, ,,
Replacement of engine parts	0·2240	,, ,,
Depreciation	0·1100	,, ,,
Interest, say 3½ per cent.	0·0646	,, ,,
Gross operating cost, including interest and depreciation	0·9714	,, ,,

This is equivalent to 10·6d. per train-mile.

The distance run by each railcar on this line, after

being put into regular passenger service in May, 1929, up to July 31, 1934, was:—

Railcar No. 1	193,329 km.
Railcar No. 2	209,506 ,,
Railcar No. 3	219,154 ,,
Total	621,989 km.

Cost of materials used in the maintenance and repair of the three Beardmore diesel-electric railcars in service on the San Sebastian-Pamplona line:—

	1932 Pes.	1933 Pes.
Engine and Mechanical Portion—		
Diesel spare parts	1,589·95	835·27
Petrol and cleaning material	866·78	800·79
Repairs to bogies, wheels and axles ..	359·71	953·89
Volute springs for the bogies	795·56	1,409·81
Electrical Portion—		
Armature repairs	221·63	327·56
Carbon brushes and fuses	315·80	419·54
Wire and other material, sundries ..	138·45	156·55
Battery—		
Complete cells (English)	1,846·35	—
Ebonite boxes (English)	516·25	187·0
Tudor plates and insulators	1,182·35	3,677·0
Sulphuric acid	82·30	—
Total pes.	7,915·13	8,767·41
Km. run by the three railcars during the year	140,620	134,773
Cost of materials per km.	0.057 pes.	0.065 pes.

The cost of these materials has already been included in the cost per train-km. given above. During the years 1932 and 1933 renewal has been made of the greater part of the positive plates of the accumulator batteries of the railcars (after 4½ years' working), and the batteries are now in first-class condition.

The diesel engines use as fuel gas-oil having the following characteristics:—

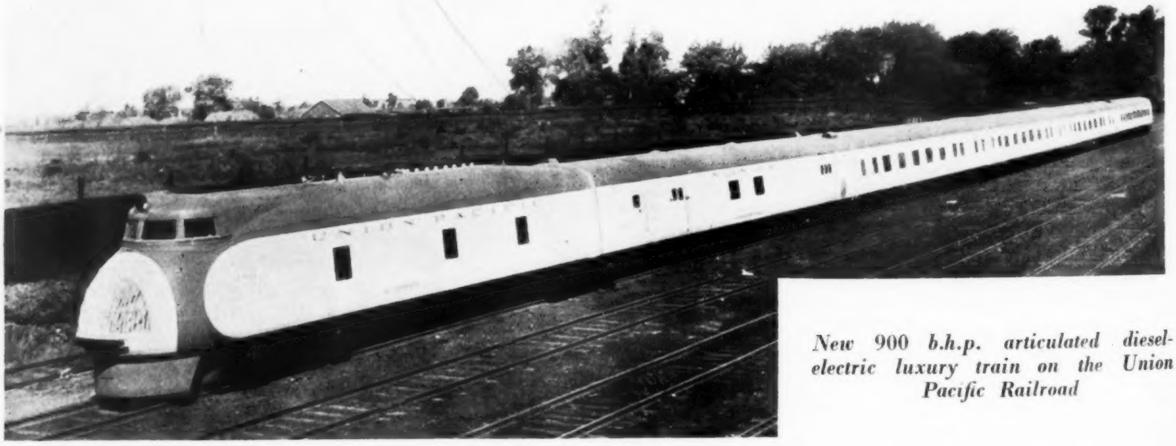
Heat value, per lb.		19,400 B.t.u.
Specific gravity at 15° C.		0·8649
Pens Martin flash point		178° F. 81° C.
Engler viscosity, ...	at 20° =	1·52
.. .. ..	at 50° =	1·24

For lubrication of the engines pure mineral oils of the Gargoyle D.T.E. type (supplied by Vacuum Oil Co. Ltd.) and the Shell C.Y.3 type (supplied by Shell-Mex L.P.B. Limited) are used. The Shell oil has the following characteristics:—

Specific gravity	0·908
Flash point in closed vessel	210° C.
Flash point in open vessel	220/225° C.
Evaporation (S.S.T.N.)	– 10° C.
Carbon residue	0·04 per cent.
Ash	—
Free acid (in mg. KOH)	below 0·05
Colour (Union)	– 6
Viscosity E. at 20° C.	90
,, 50° C.	11·5
,, 100° C.	2·1

A complete change of engine lubricant is made every eight days, that is, after a mileage of approximately 1,500 km., when the dirty oil is removed from the sump, recovered in a special plant, and used again.

NEW UNION PACIFIC SUPER-SPEED TRAIN

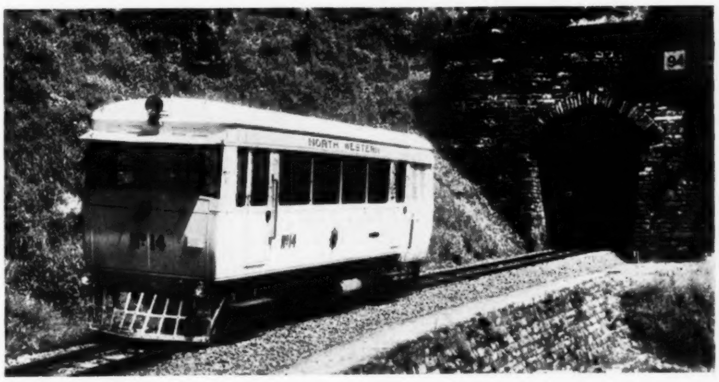


New 900 b.h.p. articulated diesel-electric luxury train on the Union Pacific Railroad

THE second streamlined passenger train ordered by the Union Pacific Railroad from the Pullman Car & Manufacturing Corporation has just been completed, and has already made a record exhibition run from Los Angeles to New York, via Chicago, covering the 3,193 miles in 56 hr. 55 min. at an average speed of 56 m.p.h. It has been claimed that for two miles after leaving Cheyenne, Wyoming, a speed of 120 m.p.h. was maintained, and that from Cheyenne to Omaha, 508 miles, the average speed was 84 m.p.h.

Composed of six articulated cars painted in gold and brown, the new train is largely constructed of duralumin, and scales 188 tons with supplies but without passengers. The first vehicle contains the 900 b.h.p. 12-cylinder two-stroke Winton diesel engine, the main generator, and the auxiliaries; the second vehicle is a mail and baggage car, but part of the space is for the train heating and air-conditioning equipment; the third and fourth cars are Pullman sleepers, and the fifth an ordinary sleeper; the last car is a passenger vehicle with a buffet at one end. The passenger-carrying capacity is 124 and the length of the train 376 ft. Four nose-suspended traction motors are mounted on the axles of the first two trucks, and all the trucks have 36-in. wheels with axles running in roller bearings. Two nine-car trains, each with a 1,200 b.h.p. diesel engine, are now being built for the Union Pacific.

DIESEL RAILCAR IN THE HIMALAYA



95 *b.h.p. diesel-electric railcar, Kalka-Simla Railway*

NO Indian railway has felt the effect of road competition more than the 2 ft. 6 in. gauge line which connects Simla, the summer capital, with the broad-gauge terminus at Kalka. In recent years most of the first-class passenger traffic in the summer has been dealt with by a fleet of petrol-driven railcars, together with an intensive system of steam trains; but the cost of operating 16-seater petrol cars up the 60 miles of tortuous single line has made the problem of competing with the motor road traffic a difficult one.

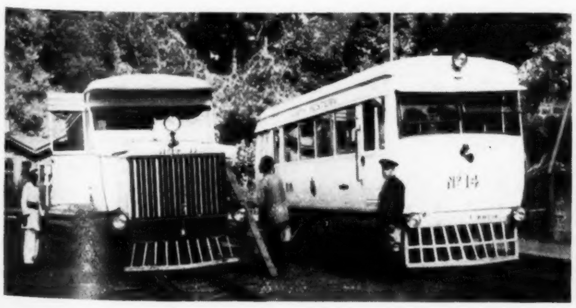
Under such circumstances it is not surprising that the railway should have put into service a diesel railcar, and by the courtesy of the Chief Mechanical Engineer of the North Western Railway we are able to describe the new vehicle, which was built by Sir W. G. Armstrong, Whitworth & Co. (Engineers) Ltd., at Scotswood, and shipped out to India and railed at Kalka in August last. The power unit is a six-cylinder Armstrong-Saurer four-stroke engine developing 95 b.h.p. and directly coupled to a d.c. generator manufactured by Laurence Scott & Electromotors Ltd. The complete engine transmission unit is placed transversely in a compartment at the back of the car, and is separated from the saloon by a small vestibule, thus isolating the passengers from noise and smell.

The driving cab, situated on the off-side at the front of the car, is separated from the saloon by a glazed partition, thus minimising obstruction to the passenger's view of the fine hill scenery through which the car runs. The main controller is of the tramcar type and the handle is fitted with a dead-man attachment. In addition to the idling, or zero position, three speed notches are provided on the controller; moving the handle to No. 1 notch causes the engine to rev. up to idling speed; No. 2 notch gives normal running speed; and No. 3 is a special notch giving increased power. This method of speed control has been designed specially to meet the abnormal conditions prevailing, viz., grades of 4 per cent. without compensation on curves of 110 ft. radius.

The most noticeable feature of the new diesel car is its apparently effortless but rapid acceleration, the vehicle appearing to glide away without any vestige of shock or harshness. In the run of 60 miles the line climbs from 2,143 ft. above sea level at Kalka to an altitude of 6,840 ft. at Simla, and on the round trip of 120 miles, the average fuel consumption does not exceed 18 gal. of oil at four annas (4½d.) per gal. Lubricating oil consumption is 500-600 m.p.g. Compared with similar petrol cars which consume 10 to 15 per cent. more petrol costing five times as much as crude oil, the economy of the diesel-electric car is at once apparent. Braking is on the Westinghouse system, with two blocks on each wheel.

In this railcar everything possible has been done to alleviate the troublesome fatigue from which the passengers sometimes suffer on this hilly line, where the track seems to be forever winding from one side to the other, and from the experience gained, the electric drive appears to impose a minimum of mental or physical exertion upon the driver, there being nothing to divert his attention from the track ahead. The car has been in daily use since the end of August, and makes one return trip a day. It appears to have an ample reserve of power, and is capable of speeds well in excess of the maximum of 18 m.p.h. allowed on the section.

A Bonniksen speedometer is provided in the cab and there is an electric wiper working up and down the wind-screen. The electric lighting is of the Lucas type, and includes, in addition to the interior lights, two fixed head lights and one swivelling light, which, actuated by a system of rods connected to the leading bogie, lights up the track ahead, no matter whether the car is travelling on the straight or on a curve. Current is supplied by an Exide-Ironclad battery, which also provides the power for starting the engine. The main dimensions of the car are: tare weight, 13 tons; length over cowcatchers, 30 ft. 1 in.; length over body, 28 ft. 5 in.; max. width, 7 ft. 6 in.; max. height, 10 ft. The car is painted white, with gold lettering, and is kept in very smart condition by the railway staff.



Diesel railcar No. 14 passing petrol car at Barogh

Diesel-electric railcar leaving Kalka station

TRANSMISSIONS FOR DIESEL LOCOMOTIVES AND RAILCARS

Recent developments in Vulcan-Sinclair couplings for traction applications

By STUART MIALL, B.Sc.

FOUR years have elapsed since the Vulcan-Sinclair hydraulic coupling first made its appearance in the automobile world under the name fluid flywheel, and already some 20,000 vehicles are driven through a fluid medium. Early in 1932 THE RAILWAY GAZETTE announced that this coupling had been made more suitable for traction purposes than the original fluid flywheel by the addition of a reservoir chamber on the back of the runner or driven member, with the object that the coupling gives an easier start from rest and has considerably less slip at normal running speeds.

The new development, known as the Vulcan-Sinclair traction coupling, has been very widely applied to railway and road haulage, and within recent months it has been still further developed to extend its sphere of usefulness for locomotive and railcar, and also to crane and winch applications.

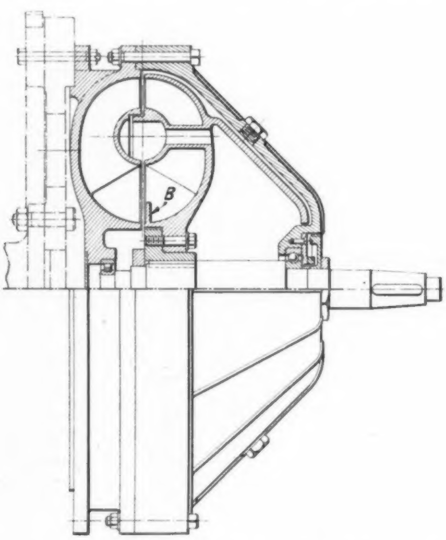


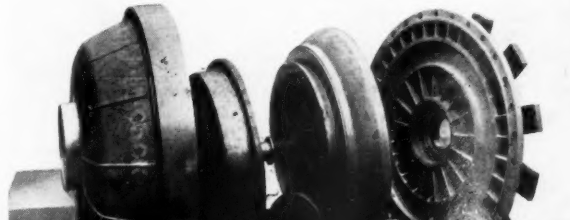
Fig. 1—Arrangement of Vulcan-Sinclair traction-type coupling with anti-drag baffle

Limitations of Fluid Flywheel

In this article the new modifications will be described. First of all, however, the limitations of the fluid flywheel and the plain traction coupling will be indicated. The chief disadvantage of the ordinary fluid flywheel is that unless it be designed to have a relatively high slip under full speed full load conditions it will transmit a very considerable drag torque at idling speeds of the engine. The commercial fluid flywheel represents a compromise, the efficiency of drive being as high as is consistent with a manageable drag torque, but not so high as could be desired. The traction coupling gives a lower drag torque than the ordinary fluid flywheel in the stalled condition, and yet has a much lower slip at normal vehicle speeds, *i.e.*, a higher all-round working efficiency. This is due to the action of the internal reservoir, which under starting conditions partly empties the working circuit formed by the impeller and runner, thus reducing the drag torque. As the vehicle accelerates, the liquid is automatically returned to the working circuit under centrifugal pressure, so that the operation is that of a completely filled low slip coupling of very high efficiency. Under starting conditions the partly-filled working circuit of the coupling is capable of transmitting full engine torque at relatively high engine speeds, but the drag torque it can transmit from an idling engine is much less than the drag of a full coupling under similar conditions. The partly-filled coupling with its runner stalled puts less restraint on the engine than a full coupling when acceleration from idling takes place, but with its impeller run up towards the speed at which the engine will deliver its maximum torque the partly-filled coupling will readily transmit that torque. Consequently, the runner is started without difficulty against the load which is thus set in motion. As the runner speed increases, the centrifugal tendency of the oil in the reservoir chamber also increases, and at a given speed this pressure is such that the oil is transferred back into the working circuit of the coupling. The efficiency of operation is high beyond this point, the slip at full power falling ultimately to below 2 per cent.

The volume of liquid supplied with the coupling is such that the working circuit is filled before the reservoir is emptied; as a result the liquid in the working circuit is under sufficient centrifugal pressure to exclude all air, and at the same time it is free to expand when its temperature is increased. The reservoir acts as an air-separating chamber so that the working circuit is kept full of the hydraulic operating medium, while the air collects in the centre of the reservoir.

In the simple fluid flywheel the absence of an expansion chamber is a distinct drawback, since the working circuit must contain a mixture of oil and air, which naturally reduces the efficiency. If the working circuit be completely filled with liquid, with no air space for expansion, and if the glands be tight, then a material increase of



Components of Vulcan-Sinclair ring-type fluid coupling showing relation of ring-valve to runner

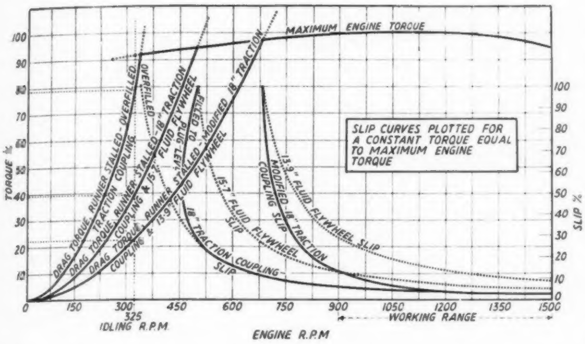


Fig. 2—Characteristics of Vulcan-Sinclair traction-type coupling with anti-drag baffle with different operating conditions and sizes

temperature will result in the bursting of the fluid flywheel casing.

The starting characteristic of the traction coupling can be readily altered to suit any particular diesel engine; *e.g.*, by varying the size of the internal reservoir chamber. Hence with a small reservoir chamber the working circuit is only partially emptied of liquid under the stalled condition, whereas with a large reservoir the quantity of liquid transferred from the working circuit when starting is greater, and hence an easier start is given without impairing the low value of slip at normal running speeds. It is also easy to adjust the characteristic by varying the quantity of liquid with which the coupling is initially filled, until a limiting point is reached when there is just sufficient liquid to fill the working circuit completely. This feature proves useful in connection with diesel locomotives where it is often found inadvisable in practice to run the engine at the minimum idling speed which it is possible to under test-bed conditions. If the engine must be set to idle rather fast, it naturally follows that the drag torque with the runner stalled can be substantial in amount, and in consequence extra work is thrown upon the rocking brake when engaging and changing gear.

Traction Coupling with Anti-Drag Baffle

If a case arises where the stable idling speed of the engine is inconveniently high, and length limitations do not permit the use of a specially large reservoir, an alternative method has been evolved, namely, to modify the hydraulic circuit of the coupling by fitting an annular baffle plate B to the runner. This is shown by Fig. 1 in relation to a normal Vulcan-Sinclair traction coupling.

When the impeller and runner are rotating normally at speeds of the order of **1,000** to **1,500** r.p.m. the slip is low and the baffle makes little or no difference to the performance of the coupling, as the centrifugal tendency of the liquid in the coupling causes the vortex ring to flatten somewhat on its inner periphery and to run clear of the projecting baffle plate. Furthermore, the rate at which the vortex ring turns " outside in " and " inside out " is comparatively low, so that if penetration of the ring by the baffle plate does take place the eddying which results will be inconsiderable. The influence of the baffle becomes important when the speed of the engine is diminished and when in consequence the runner speed falls below the limit where liquid is transferred to the reservoir. The reduced body of liquid tends to form a vortex of the largest cross section permitted by the configuration of the vaned members and to turn outside in and inside out at a high rate. Obviously the baffle must very effectively prevent the formation of any such vortex. Acting as an obstruction, it causes the motion of the fluid to become chaotic and in this way it diminishes the effectiveness of the coupling as a transmitter of torque. The drag torque of the stalled traction coupling is reduced by about **50** per cent. when this baffle is added, and the reduction is of great practical significance if the coupling is to be used with an engine which must be set to run at a somewhat high idling speed. Where a baffle is fitted the engine must be run up to a higher speed to start the runner against any given load. This is an advantage if the engine happens to be one which does not pull really well until turning at **600** to **700** r.p.m. Considered then as an adjunct to a diesel engine rather below the average in flexibility, the baffle-type traction coupling is an advance on the ordinary traction coupling and a still greater advance on the fluid flywheel.

Its characteristics are shown by Fig. **2**, in which, for purposes of comparison, curves relating to an unmodified traction coupling also of **18**-in. size and to fluid flywheels of **15·7**-in. and **13·9**-in. profile diameter are also shown. It is striking that the slip of the baffle-type coupling is no higher than the ordinary traction coupling at the high speed end of the range.

Characteristics of Traction Coupling with Anti-Drag Baffle

An overfilled traction coupling is virtually a fluid flywheel designed to give a low slip under normal operating

General view of the components of the latest type of Vulcan-Sinclair traction-type fluid coupling with anti-drag baffle

conditions and a very heavy drag torque. In Fig. 2 the lowest slip curve and the highest drag torque curve relate to an overfilled **18**-in. traction coupling. The same coupling filled to the correct level gives no greater slip over the normal working speed range, but if the impeller speed be reduced below **520** r.p.m., the torque meanwhile being kept constant at its full value, the liquid begins to leave the working circuit, and with a further small decrease of engine speed the slip becomes **100** per cent. As can be seen from the middle drag torque curve, the torque that the coupling exerts at a low impeller speed with its runner stalled is little more than half the corresponding figure for the overfilled coupling, *i.e.*, for the equivalent fluid flywheel. The dotted slip curve labelled " **15·7**-in. fluid flywheel slip " is for a fluid flywheel giving the same drag torque. It shows that the slip under normal working conditions of such a flywheel must be about double the slip of the traction coupling giving the same drag torque. Putting a baffle into the **18**-in. traction coupling almost halves the drag torque again, and as can be seen from the slip

curve, the baffle does not observably change the action of the coupling under full torque until the impeller speed falls below 1,200 r.p.m. The highest slip curve is for a 13·9-in. fluid flywheel giving the same drag torque as the modified 18-in. traction coupling. Again it is seen that for a low drag torque the fluid flywheel must be designed to give an excessive amount of slip.

The Ring-Valve Traction Coupling

In point of time the forerunner of the baffle type coupling is a coupling having the baffle movable instead of fixed. Fig. 3 shows a coupling of the traction type with a reservoir at A and having a movable baffle B, called a ring valve, in addition. This coupling combines the advantages of the traction coupling and of the ring-valve type. The baffle in this instance can be moved so as to be a complete barrier to normal fluid circulation, but its position is such that when partly closed it does not have the same dual effect as has been described for the fixed baffle in the traction coupling. Only by virtue of eddies and skin friction does the ring-valve coupling with the ring valve shut manage to exert a drag torque. Fig. 4 shows that the drag torque due to these effects is only about one-sixth of the drag torque given by the same coupling functioning as a normal traction coupling with the ring valve open. By moving the ring valve to an intermediate position the slip can be regulated to suit the requirements of load and speed, but owing to the existence of a channel over the outer periphery of the ring valve into the reservoir chamber, the liquid passes out of the working circuit more readily than in the traction coupling having no ring valve.

Ring-valve couplings were made several years ago, and are in use in different parts of the world, but the coupling shown in Fig. 3 and in other illustrations is in many

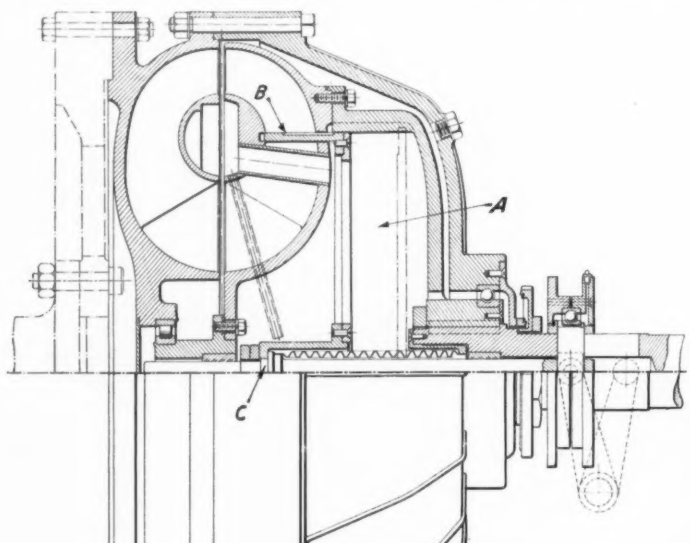


Fig. 3—General arrangement of Vulcan-Sinclair fluid coupling of the ring-valve traction type

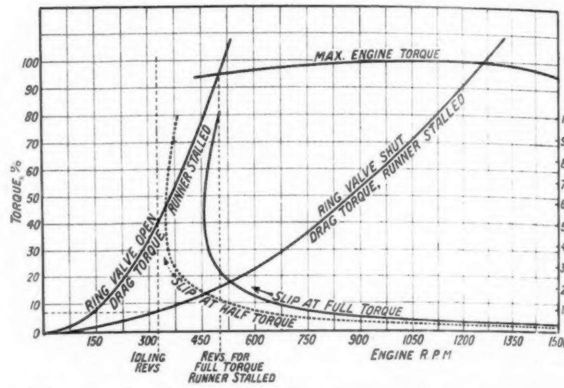


Fig. 4—Characteristics of Vulcan-Sinclair ring-valve type traction fluid coupling

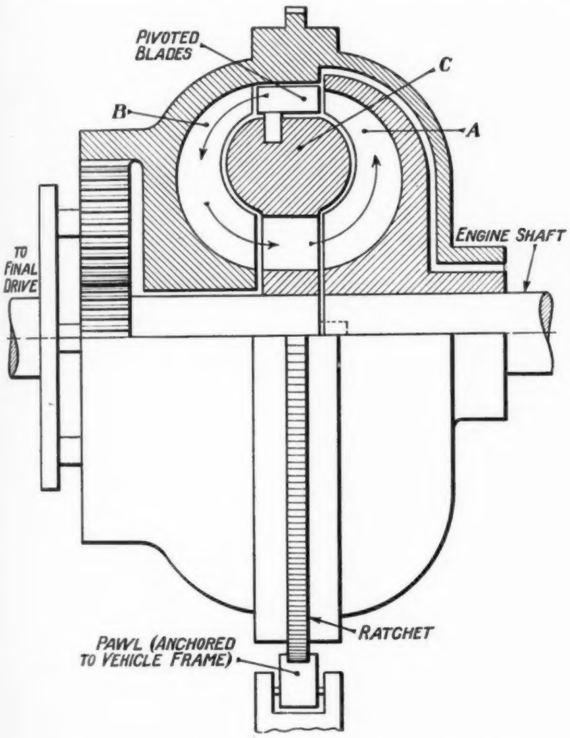
respects an advance on the older type. Besides possessing all the special features of the traction coupling it is a great improvement mechanically. The ring valve and its push rod form a single moving part in the new coupling, whereas in the older coupling there were four push rods and four operating levers. In the new coupling a flexible bronze bellows, bronze welded to the push rod C, makes oil leakage a physical impossibility, whereas in the older coupling four stuffing boxes were used. In the new coupling the ring valve forms part of the runner assembly and is immune from engine vibrations, whereas in the older coupling it formed part of the impeller assembly. The older coupling continues to give satisfactory service, but the new coupling, though cheaper to construct, seems likely to have an even better record in view of the almost complete absence of wearing parts and the total absence of leather or other packings.

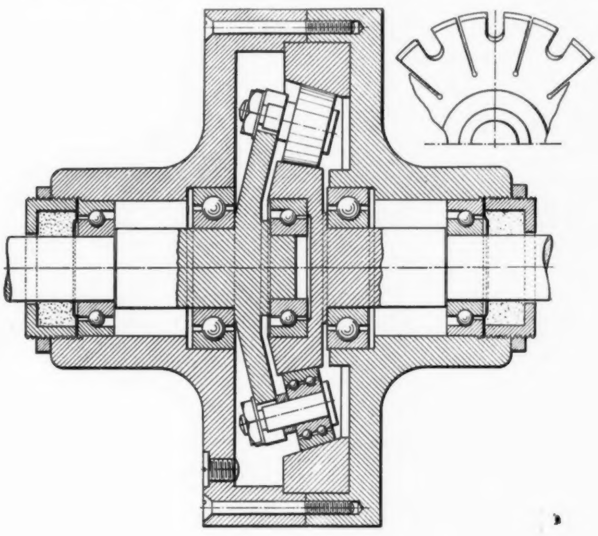
The ring valve, which is actuated by the usual fork and collar mechanism, affords a useful means of control where loads have to be started against excessive static friction. With the ring valve closed it is still possible to transmit a large proportion of the maximum torque through skin friction and eddies if the engine speed is increased sufficiently. By then withdrawing the ring valve the full circulation of the fluid is established so that the torque transmitted can be raised to several times the maximum value without causing any shock to the engine or transmission. The time during which such a torque can be sustained will, of course, be limited by the inertia of the engine flywheel, but in starting a heavy train the pull required to overcome static friction need only be momentary. The new ring-valve coupling has proved useful in industrial applications, and it has been found to facilitate the control of the load on cranes and hoists, as here again static friction plays an important part.

Thus, when the maximum load is picked up with a little slack in the rope, the engine torque may be easily sufficient to sustain it in motion. On the other hand when starting a suspended load from rest, the static friction of the train of gears may be so high that the engine torque is insufficient to hoist the load. By using the ring-valve type of coupling it is possible to obtain a momentary overload torque, as described above, to set the load quickly in motion.

A NEW FLUID TRANSMISSION FOR TRANSPORT WORK

THAT for certain purposes the fluid drive is a commercial proposition has been made apparent by the number of units now running satisfactorily with the Leyland, Voith-Sinclair and Vickers-Coates transmissions. The success of these vehicles might naturally be expected to inspire further experiments with the fluid drive, and therefore little surprise will be felt when it is announced that a fourth version of the hydraulic turbo-converter is very shortly to be the subject of tests in a road motor. Known as the Dellread Automatic Gear, and developed by the Dellread Gears (Holdings) Co. Ltd., of 2, St. Ann's Lane, Great Peter Street, London, S.W.1, this new turbo-converter has already shown promise in model form. It is not proposed to give any test figures here, as a fair estimate of the merits of the gear could not be based on results obtained from so small a unit. The invention itself may be described however, and it will be apparent that it possesses some of the features of its successful forerunners. Coupled to the engine is a vaned member A similar to one half of a fluid flywheel. The other half, B, is situated behind this, but with a sufficiently large gap intervening to permit the introduction of a third member C. Member B acts as a fixed reaction unit when torque multiplication takes place, but being held stationary by a freewheel, its restraint is one-sided only, and, except at starting or when hill-climbing, it turns in the same direction as the member A. Member C carries vanes which pivot about radial axes near their centres. Springs normally hold these vanes in a position roughly parallel to the converter axis, but when fluid impinges on them they turn away in such a direction as to direct the fluid backwards against the vanes of member B which is held stationary by the freewheel. Member C carries on its shaft the sunwheel of an epicyclic gear, the annulus of which is on the back of member B. The vehicle is propelled by the planet carrier which has a speed governed by the speeds of C and B. As the engine is started, C endeavours to rotate forwards while B tries to turn backwards, not only because of the backwardly-directed fluid from C, but because also of the reaction on it as the annulus of an epicyclic gear. The torque on the planet carrier is related to that exerted by the sunwheel of C (being in fact three times as high, while the annulus remains stationary) and when the engine speed is sufficient the planet carrier overcomes the vehicle resistance and begins to rotate. Thereafter the speed of A relative to C becomes less and consequently the vanes of the latter experience a reduced deflecting force and turn back towards their normal position. If the torque output required is not very high these vanes ultimately cease to direct the fluid backwards and then the fluid torque on B instead of being backwards becomes forwards as in a fluid flywheel. When this forward torque exceeds the backward reaction on its annulus member B will commence to rotate forwards. No torque multiplication is effected under the new conditions but as the speed of B approaches the speed of A the efficiency must come up from a figure of 33-1/3 per cent. to one depending on the final ratio borne by the speed of the planet carrier to the speed of A. In the lighter Dellread units it is proposed to use a friction reduction gear in place of one having toothed wheels. In this the sun planets and annulus are all tapered rollers and the whole forms what is to be known as an Epirolic reduction gear.



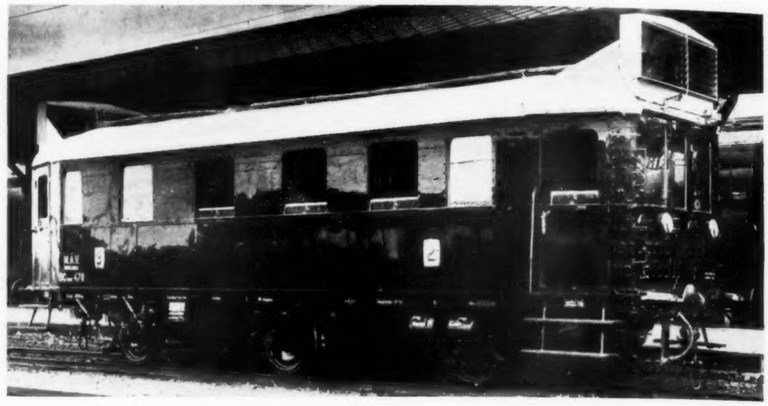


Left: Diagrammatic arrangement of the new Dellread automatic hydraulic transmission

Above: Sectional arrangement of Epirolic reduction gear

DIESEL RAILCAR PRACTICE IN HUNGARY

Extensive operation of diesel vehicles in local service is now being supplemented by high-speed cars on main lines and fast railbuses on local lines



Top right: A standard six-wheeled Ganz diesel-mechanical railcar on the Hungarian State Railways
Above: Special railcar shed at Szentes with accommodation for 24 vehicles

IN 1926 the Hungarian State Railways acquired two 150 b.h.p. double-bogie railcars, one with a Maybach engine and the other with a Ganz unit, but although these cars gave satisfactory results, it was not until the slump of **1929-30** that diesel traction was seriously adopted. Since that time over **90** diesel railcars have been set to work on the State Railways and practically all of these are engaged in local services, where, since their introduction, the increase in passenger traffic has varied from 15 to 65 per cent.

Apart from the original Maybach vehicle of **1926**, all the diesel cars of the Hungarian State Railways have been built throughout by Ganz & Co. Ltd., of Budapest, and all are fitted with mechanical transmission and Ganz-Jendrassik engines. The most numerous class is powered by 110 to 150 b.h.p. engines; the first batch were built as four-wheeled cars with a gross weight of 22·5 tons, but as there are many branch lines which can take an axle load of only 9 tons, the more recent cars of this power have been fitted with three axles, and the first batch are being converted as they come in for heavy overhauls. A detailed description of the four-wheeled vehicles and their working costs was given in the *Diesel Railway Traction Supplement* for March 24 and April 21, 1933.

One or two trailers are usually hauled, and the average working cost of these trains over the last 15 months has been just over 5d. per train-mile, made up as follows: fuel oil 1·79d.; lubricating oil 0·35d.; wages of train crew 1·15d.; maintenance 0·40d.; main overhaul 1·38d.; total 5·07d. The railcars are operated on the star system, such as has been introduced in France, a number of railcars being shedded at a junction station and working out in

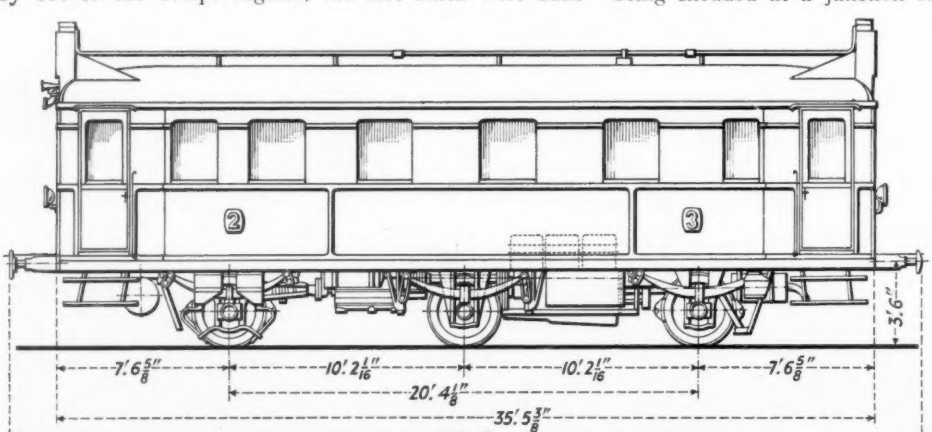
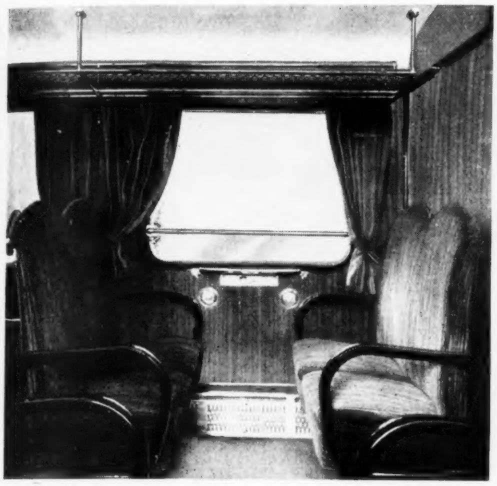


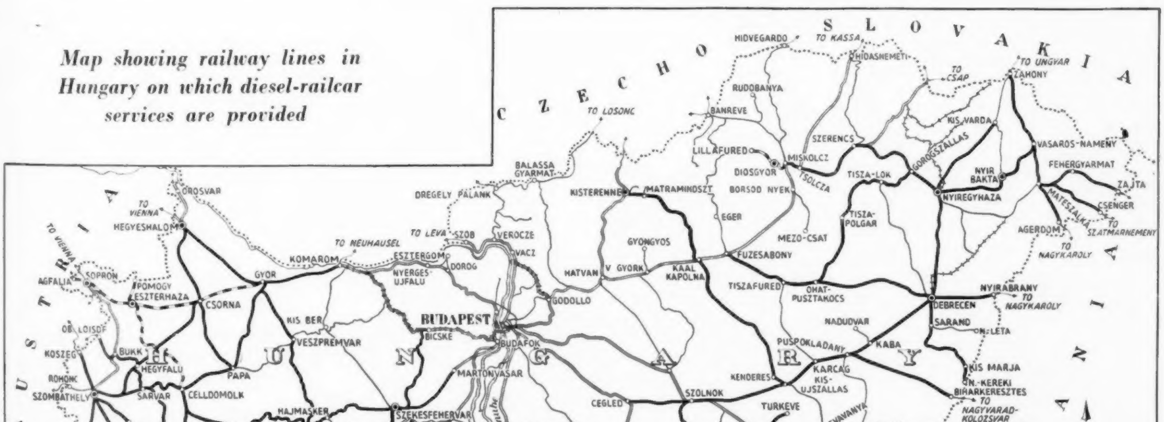
Diagram of standard Ganz six-wheeled car of 110-150 b.h.p. with a maximum axle load of 9 tons, as used for local and branch line trains on the Hungarian State Railways



all directions. The situation of the main railcar sheds is indicated on the accompanying map. At several places entirely new sheds have been built for the diesel railcars, and one of these is illustrated on the opposite page; it is located at Szentes, and has accommodation for 24 vehicles.

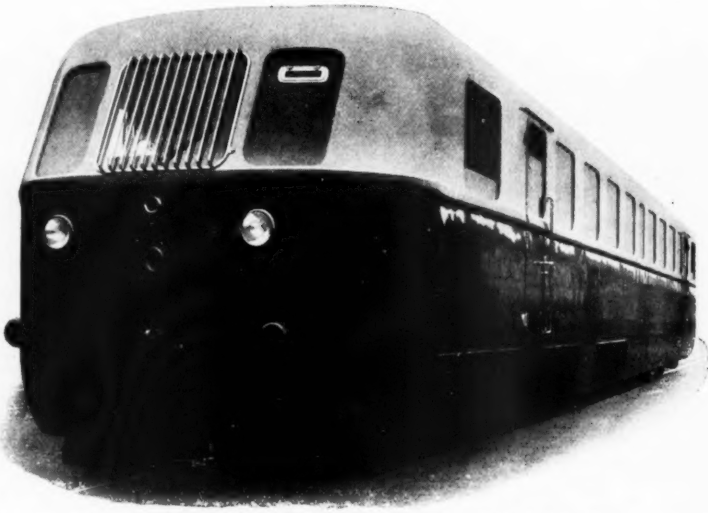
A daily inspection of each railcar is made by the driver, and any necessary adjustments made, the oil level in the engine crankcase inspected, and the grease boxes tightened up. At the end of the week the lubricating and fuel oil filters, and the fuel pump constituents, are examined and cleaned, and a fresh supply of lubricant given to the engine. The car is cleaned and the mechanical portion and engine equipment inspected. After running approximately 5,000 km. (3,100 miles) in local service, that is, about every four weeks, a light overhaul is carried out at one of the central car sheds. The engine, transmission, and mechanical equipment are examined without dismantling the parts, and the fuel nozzles, air and oil filters are thoroughly cleaned. The lubricating oil in the engine crankcase is drawn off and replaced by a fresh supply; the length of the fuel pump strokes is checked, and the oil in the change-speed and reversing gearboxes is replenished. The time taken by this overhaul amounts to a full half-day. With the fast railcars now being introduced on certain Hungarian lines, the mileage between these weekly overhauls amounts in some cases to nearly 6,000.

A more thorough overhaul is given once in three months, that is, after a distance of 15,000 km. (9,500 miles) for cars in local traffic, and up to 30,000 km. (19,000 miles) for cars engaged in fast service. This overhaul takes two or three days, and the engine cylinder heads are removed, pistons and cylinders examined, valves re-ground, piston rings cleaned and, if necessary, renewed. The gearbox covers are removed and the mechanism examined, and the remainder of the vehicle inspected and repaired as required. Every six months an overhaul lasting from four to six days is given, and in addition to the items of inspection just enumerated, the engine cylinder blocks are removed, the main bearings and timing gears adjusted, and the lubricating and fuel oil pipes cleaned. The vibration damper is examined, and if required, fitted with a new friction lining. The brake equipment, air compressors, and auxiliary electric apparatus are examined, and the whole car overhauled. This work is all carried out in one of the central sheds, but two carriage fitters are borrowed to overhaul the body and underframe. Finally, after approximately two years in traffic, each car is given a heavy general repair, which means approximately 30 days out of traffic.



Map showing railway lines in Hungary on which diesel-railcar services are provided

As a result of experience with the 110-150 b.h.p. cars, the maintenance of which is described above, and of the newer 95 and 275 b.h.p. fast cars, Ganz & Co. Ltd. calculate that the operating cost of a train consisting of one 110-150 b.h.p. railcar and three trailers (with a total seating capacity of 210) would amount to 11·2d. per train mile including allowances for interest and depreciation, and assuming a yearly mileage of 60,000 km. (37,300 miles). The same firm also consider that one of the 275 b.h.p. railcars, illustrated on this page, can maintain a yearly mileage of 120,000 km. (75,000 miles) at the same cost (11·2d.) per mile, these costs being based on the present rate of exchange, viz., 16¾ pengos to the £.



New 275 b.h.p. Hungarian diesel-mechanical fast railcar

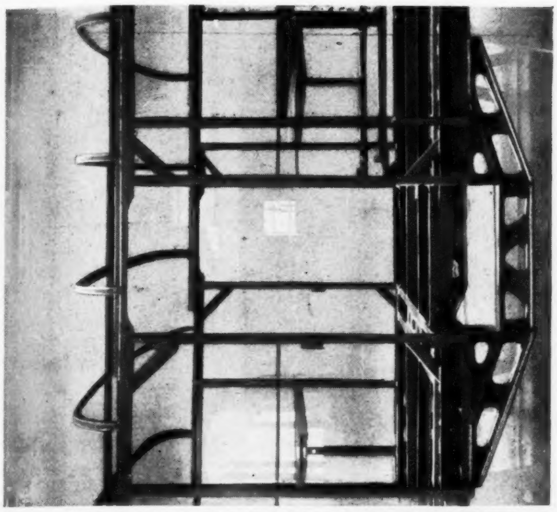
Within the last few months the Hungarian State Railways have put into service three new types of fast cars. The first is a 275 b.h.p. double-bogie vehicle seating 72 persons on a tare weight of 30 tons and having a top speed of 120 km.p.h. (75 m.p.h.). This type of car was illustrated in the issue of this Supplement for August 10, but was erroneously described as having electric transmission. Actually, it has a five-speed gearbox which, together with the engine and cooler, is mounted directly on the driving bogie. The length over buffers is 22 m. (72 ft. 3 in.); the bogie centre distance 15·4 m. (50 ft. 6 in.); the driving bogie wheelbase 3·95 m. (12 ft. 11 in.); and the carrying bogie wheelbase 2·5 m. (8 ft. 2½ in.). These cars have shown themselves capable of an acceleration, when fully laden, of over 1·0 m.p.h. p.s. up to 25 m.p.h., and 0·5 m.p.h. p.s. up to 50 m.p.h.

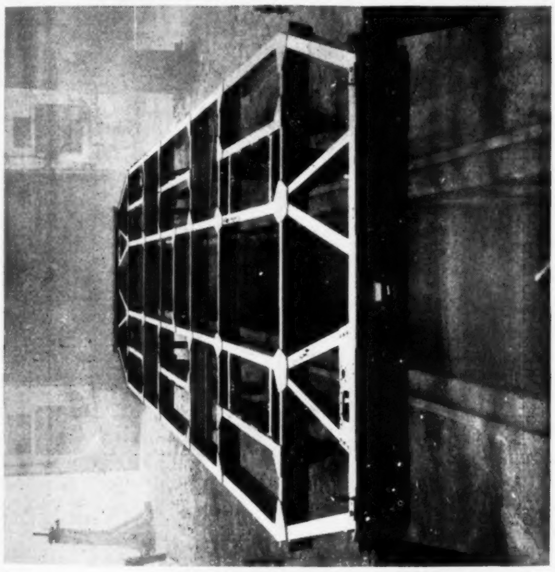
It is intended first of all to place these 275 b.h.p. cars in express service on the main Budapest-Vienna line, 290 km. (180 miles) long, and special fares have been introduced to compete with road and air interests. The schedule time is to be reduced to approximately 3 hr. compared with the 4½ hr. of the steam express trains and the 6½ hr. of long distance road motor coaches. Speeds up to 128 km.p.h. (80 m.p.h.) have already been attained on trial runs.

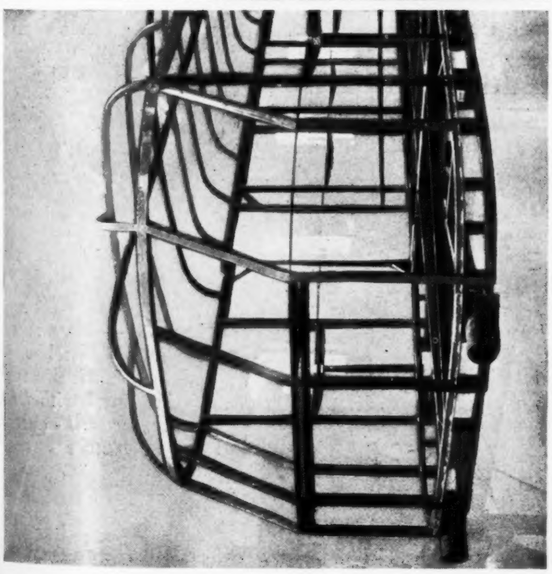
Special trials have also been carried out on the Vienna-Semmering line of the Austrian Federal Railways, and the 28·5 km. (17·7 miles) uphill at 1 in 40 from Gloggnitz to Semmering were covered at an average speed of 52·5 km.p.h. (32·5 m.p.h.) including two stops. After starting on the 1 in 40 grade, a speed of 50 km.p.h. (31 m.p.h.) was attained in 2 min. 30 sec., and the whole journey from Vienna to Semmering, 103 km. (64 miles), was accomplished in 83 min., including several stops, equivalent to an end-to-end speed of 75 km.p.h. (46·3 m.p.h.).

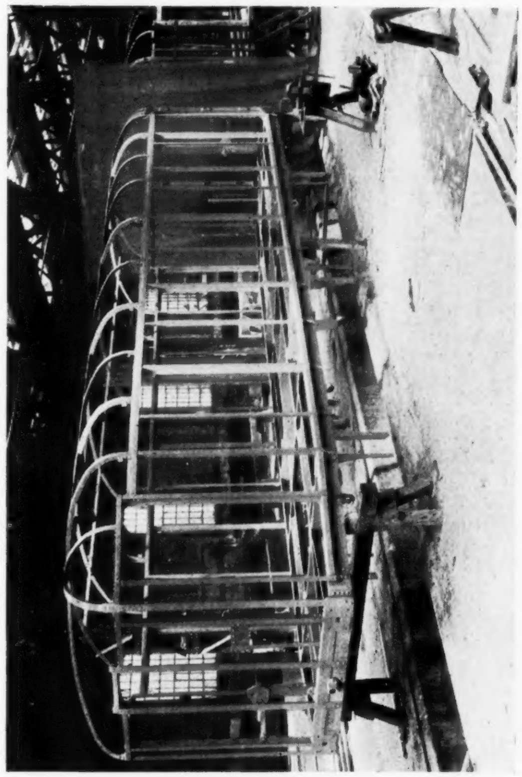
The second new type of Ganz car to be acquired by the Hungarian State Railways is a double-bogie vehicle with two engines, each of 220/275 b.h.p. Two of these vehicles are to be delivered, and they will be used for working trains of three trailers at a maximum speed of 90 km.p.h. (56 m.p.h.), and ten trailers at 60 km.p.h. (37·3 m.p.h.). The last new design is a very light four-wheeled railbus as shown in the two illustrations at the bottom of this page. Two of these railbuses are now in service, and carry 36 passengers on a tare weight of 9 tons, the weight when fully laden being 12 tons. Lavatory accommodation is also provided. The engine develops 95 b.h.p. at 1,650 r.p.m. in eight cylinders having a bore of 105 mm. (4·15 in.) and a stroke of 140 mm. (5·51 in.). The maximum speed on the track is 90 km.p.h. (56 m.p.h.). The gearbox is situated at the midlength of the car, below the floor, and the drive is taken thence to a reduction gear on the rear axle. Trailers are not hauled.

Two views of the new 95 b.h.p. Ganz diesel-mechanical railbus, Hungarian State Railways









Above: Methods of construction of body and underframe of Hungarian diesel railcars

Below: Ganz engine and gear drive mounted directly on bogie

Right: Body framing of diesel railcar, Hungarian State Railways

MECHANICAL TRANSMISSIONS FOR RAILCARS

Swiss oil-operated system has given satisfactory results over a number of years, and has recently been applied to French vehicles

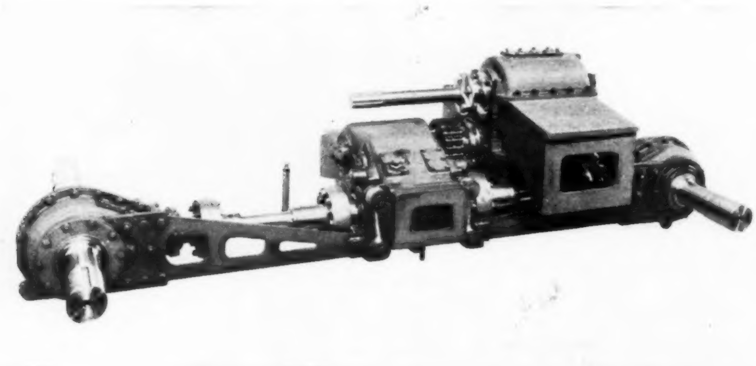


Fig. 1.—Mechanical transmission with SLM-Winterthur fluid clutches as used on 185 b.h.p. railcar

ONE of the most interesting problems which has followed in the wake of the widespread adoption of diesel railway traction is the design and operation of an efficient transmission system, and all the main types have been described in the pages of THE RAILWAY GAZETTE and the *Diesel Railway Traction Supplement* from time to time.

The service and running conditions of diesel railcars demand qualities in design not found in a locomotive. They must combine lightness with rigidity in construction and flexibility in operation, and they must possess high rates of acceleration and retardation, low first cost and maintenance charges, and simplicity of handling. Experience in various parts of the world has indicated that with such vehicles mechanical transmission in the majority of cases gives satisfactory results, especially where efficient clutch and gear-changing devices are available.

A type of transmission which has shown reliable service over a number of years is the SLM-Winterthur oil-operated gear made by the Swiss Locomotive & Machine Works, and the British patents for which are held by Modern Wheel Drive Limited, of 18, Victoria Street, London, S.W.1. This system was originally evolved about 10 years ago and was fully described in THE RAILWAY GAZETTE for July 15, 1932. It has been in operation for more than eight years on locomotives and railcars in Europe and five in Siam, and has more recently been applied to a number of railcars in France, including the Decauville car on the Nord (see *Diesel Railway Traction Supplement*, March 23, 1934), and the Acieries du Nord car on the P.O. (*ibid*, October 5, 1934). Further cars of the latter type, but with 300 b.h.p. engines, have been delivered to the Etat and ordered by the P.O. Railway.

The essential part of the SLM-Winterthur transmission is the change-speed gear with couplings operated by oil under pressure. The number of speeds varies according to the conditions imposed by the service, but normally there are four or five. The gearwheels of all steps are constantly in mesh. With this change-speed gear the main coupling is unnecessary, as each speed has its own coupling, or clutch, located within the large toothed wheels on the secondary shaft. An examination of Fig. 3 shows that the coupling consists of two exterior discs with concentric grooves which form a hollow toothed wheel, and which, when disengaged, turn loose on the hubs of the interior discs, or clutch plates. The latter, with identical concentric grooves, can move axially on the secondary shaft, which is provided with longitudinal splines. It is a three-step change-speed gear which is shown in Fig. 3, and two of the couplings are shown in section, one engaged and the other disengaged.

The engagement of any speed is effected by a distri-

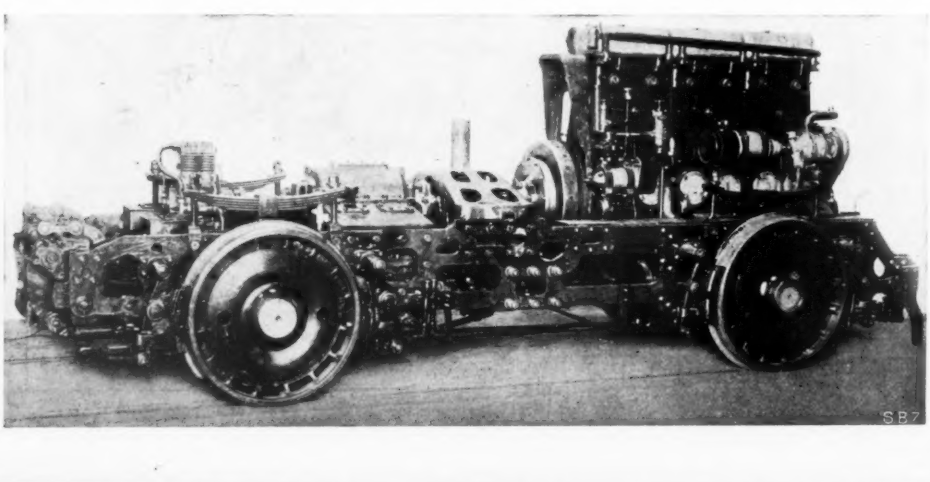


Fig. 2. — Assembly of 185 b.h.p. diesel engine and mechanical transmission fitted with SLM-Winterthur oil-operated clutches

buting cock which directs the oil under pressure between the interior faces of the toothed discs. The cock is so arranged that while one coupling is being engaged all the other steps are automatically disengaged. The primary shaft of the gearbox is connected to the engine, whereas the secondary shaft is generally coupled to the reversing gear, which has couplings of the dog clutch type operated by a lever or by compressed air.

The use of horizontal cardan shafts connecting the reversing gear to the driving axles, and the avoidance of all angular leads is an important advantage of the normal design, for the gearbox is so arranged that the difference in height between the engine shaft and the axles is absorbed by the normal centre distances of the gear shafts. The axle drive usually consists of a simple set of bevel gears. As a rule, the entire engine-transmission combination is mounted directly on the bogie.

The transmission for a diesel engine developing 185 b.h.p. at 1,000 r.p.m., as shown in Fig. 1, weighs only 5,960 lb. including the driving axles. All parts are of rigid construction and the brackets on which the change-speed and reversing gear are suspended in the bogie are of substantial design, and serve also as cross-stretchers for the bogie frames. A similar unit for a high-

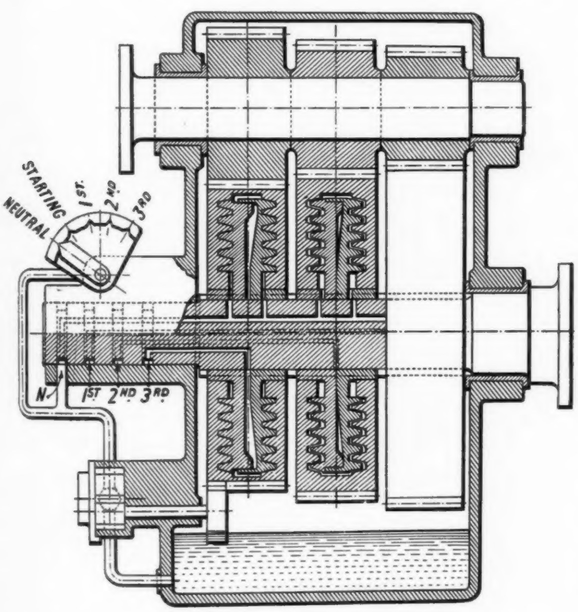


Fig. 3—Diagrammatic arrangement of SLM-Winterthur oil-operated clutch

speed railcar with an engine developing 300 b.h.p. at 1,500 r.p.m. weighs only 6,620 lb., including the suspension brackets, which also act as cross-stretchers and carry certain parts of the brake rigging.

Starting, Speed-Change and Acceleration

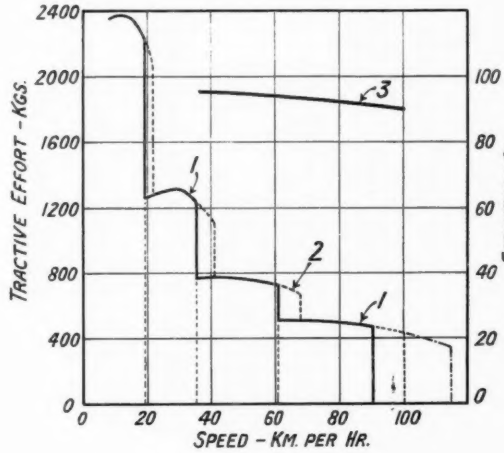
Smooth and shockless starting is effected by the admission of oil at below full pressure. The three positions of the switch cock correspond to:—

(a) Neutral position. All couplings disengaged.

(b) Starting position. The coupling of the first speed under oil at reduced pressure.

(c) Position for first speed. The coupling of the first speed is under oil at full pressure.

By moving the switch cock handle further round its sector three more positions are gained, and in each of



Curve 1.—Tractive effort with normal engine revs.
Curve 2.—Tractive effort with 10 per cent. higher speed
Curve 3.—Efficiency of mechanical transmission

Fig. 4—Characteristics of 185 b.h.p. mechanical transmission

these the oil under pressure is directed to the clutches of the corresponding speeds. The change from one speed to another is carried out solely by turning this cock, and the transition is almost immediate.

The relations between the tractive effort, speed, and transmission efficiency of the installation shown in Fig. 1 are indicated in Fig. 4. By reason of the high efficiency, and notwithstanding the tractive effort steps, accelerative values are obtained which equal those given by certain electric transmissions, and at high speeds even exceed them. The curves A and B in Fig. 5 give the speed-time values obtained on the level and on a grade of 1·2 per cent. (1 in 83) with a car weight of 37·5 tonnes. Reading from Curve A it is seen that a speed of 100 km.p.h. (62 m.p.h.) is reached in 140 sec. when on the level.

Operating Mechanism

Gearboxes of the type just described can be operated by any system of mechanical, pneumatic, or electro-pneumatic control capable of transmitting or supplying the trifling effort required for turning the distributing cock. There is no difficulty in providing a railcar with two gearboxes and two driving bogies to operate simultaneously. Slight temporary differences in the synchronisation of the

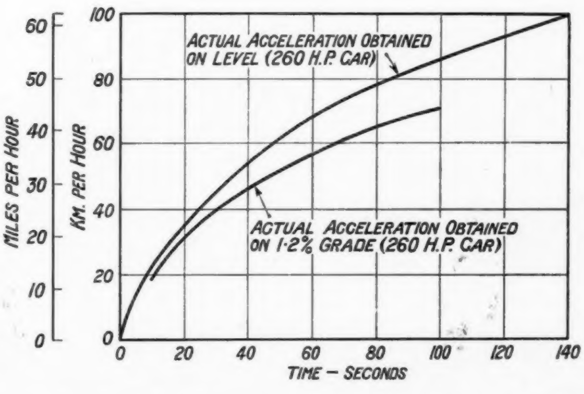
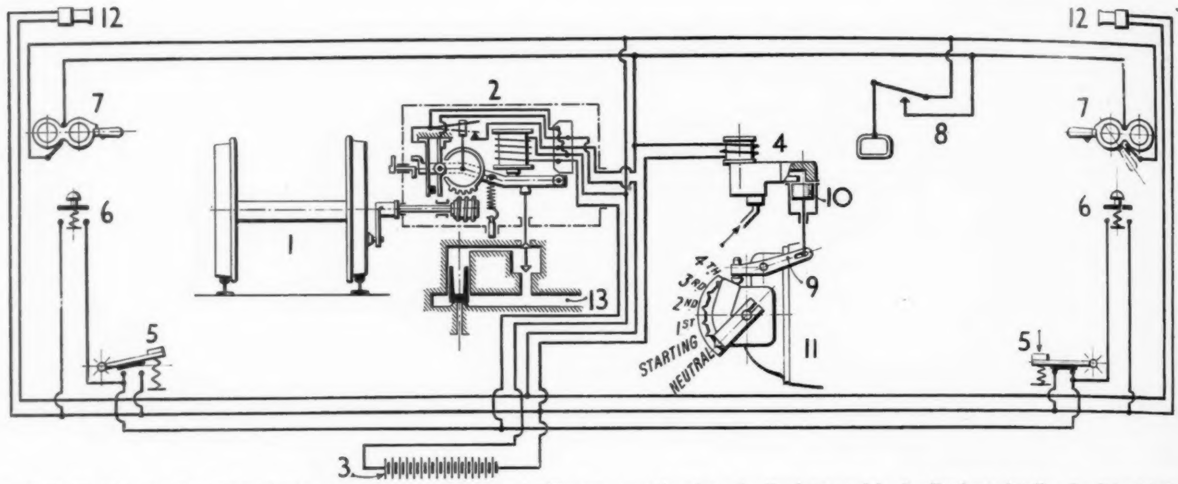


Fig. 5—Acceleration curves of 260 b.h.p. diesel-mechanical railcar



1—Wheel and axle. 2.—Brown-Boveri safety apparatus. 3.—Battery. 4—Electro-pneumatic valve. 5.—Dead-man pedal. 6.—Dead-man handle. 7.—Driver's brake valve. 8.—Emergency handle. 9.—Starting cock lever. 10.—Piston. 11.—Control cock. 12.—Alarm signal. 13.—Air-brake system.

Fig. 6—Diagram showing operation of safety device with mechanical transmission

two engines are readily absorbed by the couplings, and an absolute synchronism of the two power sets is not essential. The reversing gear, which as a rule is of the mechanical type with dog clutch couplings, is normally operated by compressed air. The equipment of the driver's stand, or stands, is consequently reduced to one lever for the operation of the gearbox and a second lever for the reversing gear.

Safety Devices

The SLM-Winterthur transmission is suitable for use in conjunction with various safety devices such as free wheels, dead-man handles, automatic train control, emergency engine governors, and automatic disengaging appliances for emergency braking.

In Fig. 6 is shown the operation of a dead-man handle attachment consisting of a combined disengaging arrangement and Brown-Boveri safety apparatus. Release of the pressure on the driver's foot-pedal 5, causes the safety appliance 2 to function, and after a run of about 90 to 100 yd. this excites the coil of the electro-pneumatic valve 4. Under the action of the piston 10, the lever 9 of the starting cock is at that moment moved to the free running position, thus causing the automatic disengagement of the gearbox drive. At the same time the air brake comes into action. It will be seen from the illustration that the coil of the electro-pneumatic valve can be excited, and the instantaneous disengagement obtained, by pulling the emergency handle 8, or by making an emergency application of the brake by means of the driver's brake handle 7. The emergency governor to prevent overspeed of the engine and the automatic train control apparatus operate the safety appliance in a similar manner, but for the sake of simplicity are not indicated.

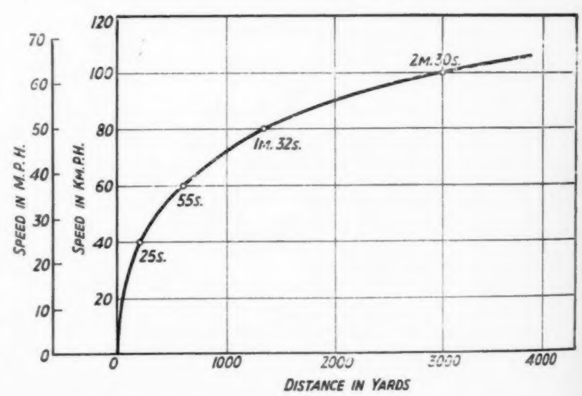
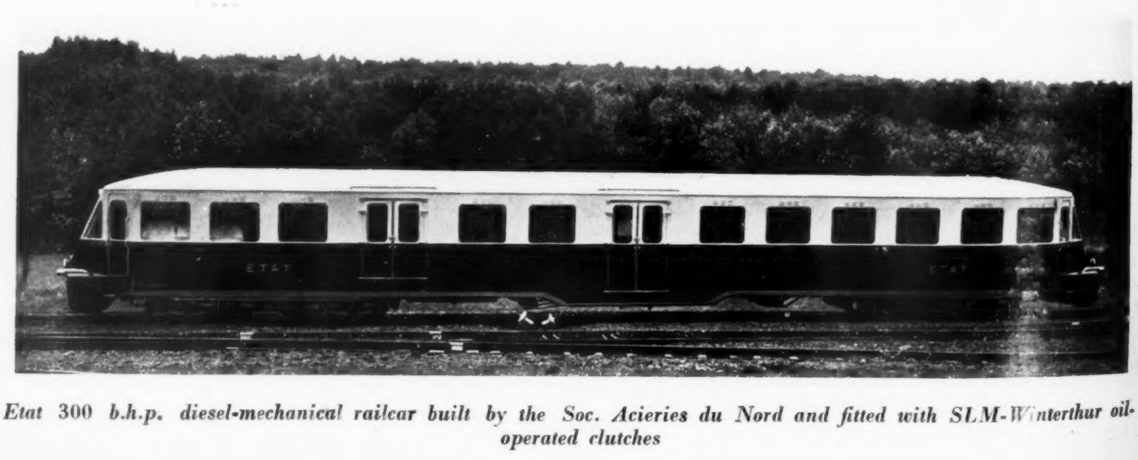


Fig. 7—Acceleration curve of 300 b.h.p. diesel-mechanical railcar illustrated below



Etat 300 b.h.p. diesel-mechanical railcar built by the Soc. Acieries du Nord and fitted with SLM-Winterthur oil-operated clutches

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